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PROPAGATION OF GRAPEVINES

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PROPAGATION OF GRAPEVINES

H. E. JACOB[1]

GRAPEVINES may be propagated by seeds, cuttings, layers, and grafts. New vines grown from seeds normally differ markedly from the parent vine and from each other. As they are usually inferior to the parent vine in vigor, productivity, and quality of fruit, seed propagation of vines to be planted in a vineyard is impractical. The seeds are useful only in producing new varieties. Propagation by cuttings, layers, or grafts, on the other hand, produces new vines identical with the parents in all varietal characteristics. Propagation by cuttings, being most economical, is universally used except with vines that must be grown on special rootstocks or with certain varieties of which cuttings are very difficult to root. Even when the desired variety is grafted on special rootstocks, the rootstocks are usually propagated by cuttings.

CUTTINGS

A cutting is a piece of the parent plant, such as a stem, root, or leaf, which, when placed under conditions favorable for growth, will develop into a new plant. For grape cuttings, sections of canes (matured current season's growth) are always used.

Selecting the Parent Vines.—Cuttings should always be taken from healthy, vigorous vines having well-matured canes. Vineyards of mixed varieties should be avoided unless the vines of the desired variety are carefully marked during the summer, when they can be clearly identified. The best cuttings come from mature vines that have made a good growth, borne a moderate crop, are free from disease, and have not been pinched or topped nor severely injured by autumn frosts. Vines that have suffered from drought or disease or which have been defoliated by insects or frost before the wood is mature yield poor cuttings. Wood from one- or two-year-old vines is often immature, and wood from vines that have borne excessive crops is often poorly nourished. Using cuttings from either is apt to give a poor stand in the nursery. Cuttings from vines grown in moderately warm regions are usually better nourished, better ripened, and therefore more desirable than those taken from vines grown in excessively hot regions.

Usually little or nothing can be gained or lost by selecting parent vines on the basis of past performance. Sports (bud mutations) do occur in

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vines, as in all other plants, and have been the origin of many varieties. Except in rare instances of bud mutation, we need not concern ourselves whether the vines from which we get our cuttings have consistently borne larger or smaller crops, grapes smaller or larger, darker or lighter colored, sweeter or sourer than the average for the variety. Variations in these respects are chiefly caused by variations in soil, climate, and culture; and the new vines will vary in the same way according to the conditions under which they are grown. In an investigation[2] carried on by the California Agricultural Experiment Station, production records of individual vines in a Muscat vineyard were kept for five consecutive years. Then one lot of cuttings was made from the heaviest-yielding vines in the vineyard, and another lot from the lowest-yielding vines. A new vineyard established with the vines produced from these two lots of cuttings failed to show any correlation between the productivity of the parent and the progeny vines.

Time to Make Cuttings.—Cuttings should be made while the vines are dormant. Good results may be expected with cuttings made at any time from a few days after the leaves fall until a few weeks before growth starts the following spring. Though it is usually considered good practice to make the cuttings during late fall or early winter, yet if for any reason the cuttings must be made from weak or poorly ripened vines, better cuttings may be obtained if not made until most of the severe winter weather is past. The weakest canes will have been killed during the winter and may be eliminated if the work is delayed until late winter or very early spring, whereas if the cuttings were made early in the dormant season, many of these weak canes would be included in the wood used for the cuttings.

The cuttings must be made as soon as possible after the vines are pruned. In cool, wet weather the prunings may lie in the vineyard a week or two without injury. Two or three days, however, of warm, dry, windy weather may dry them out to such an extent that cuttings made from them will grow poorly or not at all.

Selecting Wood for Cuttings.—Well-nourished, well-matured current season's wood growth (canes) from any part of the vine is suitable for cuttings. There appears to be no reason to avoid water sprouts and other canes that bore no crop, or even laterals of proper quality from primary canes. The most desirable canes for cuttings are medium sized, with moderately short internodes (fig. 1). Very short internodes usually indicate disease or poor growing conditions. Very long internodes indicate

[2] Bioletti, Frederic T. Selection of planting stock for vineyards. Hilgardia 2:1–23. 1926.

very rapid growth; such canes are usually soft and poorly nourished, hence low in stored reserves (starches and sugars). The outer bark should be clear, light brown or purplish brown, according to the variety, and without dark blotches, dead streaks, or immature areas. When the cane is cut the inner bark should appear green and full of sap; the wood firm, well stored with reserves,[3] and free from dark specks; the pith of moderate size, clear, and light-colored. Canes unusually flat or angular in cross-section should be avoided.

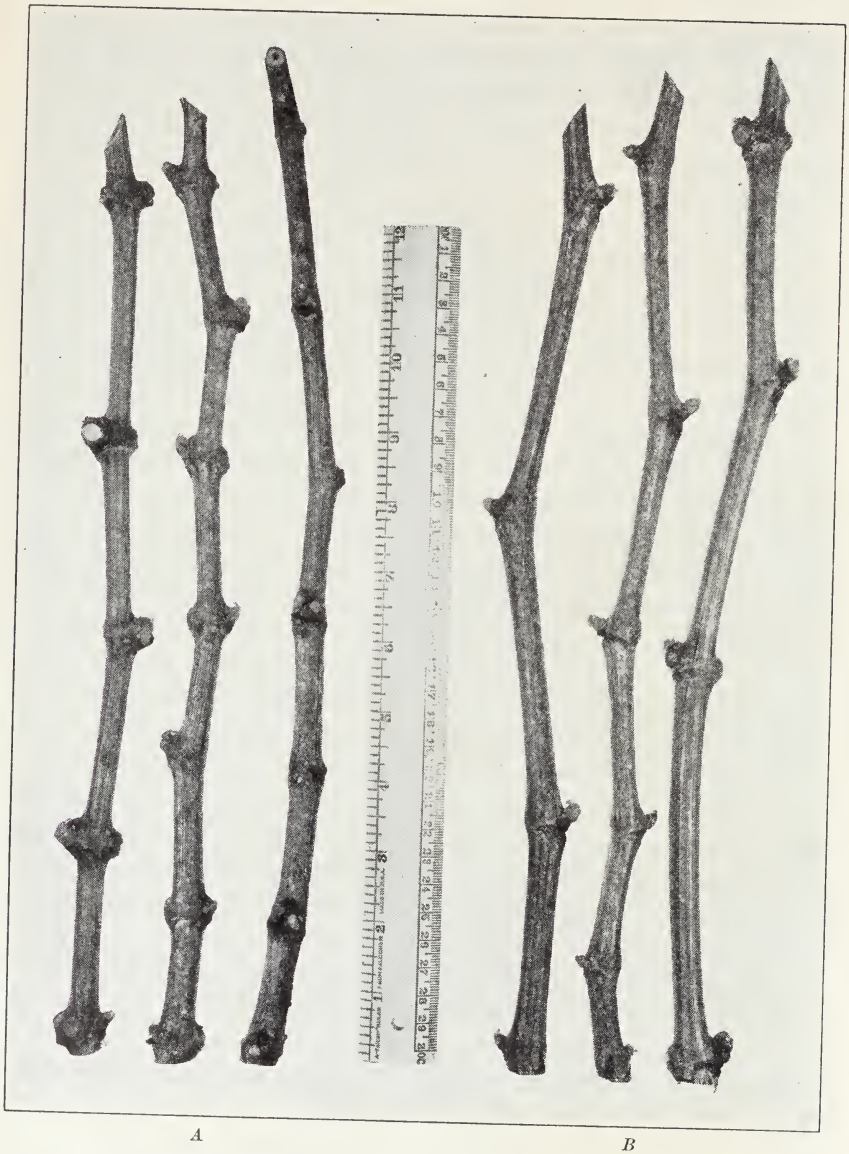
Cuttings ⅓ to ½ inch in diameter are most commonly used. Those less than ¼ inch at the small end should usually be avoided. Those larger than ¾ inch are often looked upon with disfavor; yet the only valid objection appears to be their bulkiness. When only well-matured, normally developed canes are used for cuttings, the wood is seldom too large in diameter.

Manner of Making Cuttings.—The length of cuttings used for nursery planting usually varies from 8 to 18 inches. The most common length is 12 to 14 inches from the base to the top bud. The cutting should be long enough so that when the rooting is planted in the vineyard the main roots at the base of the original cutting are below plow depth. Unless wood of the particular variety is very scarce, therefore, the cuttings should seldom be less than 10 inches long. For direct planting in the vineyard, which is seldom advisable owing to the difficulty of obtaining a good stand, somewhat longer cuttings are preferred than for nursery planting. Cuttings for this purpose are commonly made from 18 to 24 inches long. The looser and drier the soil and the hotter the climate, the longer the cuttings should be. In wet, heavy soil in the cooler regions, short cuttings are preferable. In any case the base of the cutting when planted should be at the depth most favorable to root growth. In a heavy soil in the cooler regions this may be only 8 or 10 inches deep; in a coarse, gravelly soil in a hot region, as much as 16 or 18 inches.

The cut at the base (lower end) of the cutting should be made as close as possible to the node without injury to the diaphragm or cross partition (fig. 1). If a part of the internode is left below the node at the base, the cut surface does not heal over rapidly, and decay-causing organisms may gain entrance into the main body of the vine.

At the top of the cutting, from ¾ inch to 1½ inches of the internode is left above the uppermost bud to protect the latter against drying out or other injury. If the top cut is made at an angle of about 45 degrees

[3] When ordinary tincture of iodine, diluted with an equal volume of water, is applied to the freshly cut surface of a cutting well supplied with reserve foods, a deep bluish-black staining should appear throughout the wood of the cut surface, and a very dark staining in the medullary rays.



A B

Fig. 1.—Grape cuttings of desirable character: *A*, variety, Muscat of Alexandria; *B*, Emperor.

with the cutting, there will be less injury through cracking or crushing the wood with the shears than if the cut is made straight across. The lower cut is made straight across, since slight bruising or cracking of the lower end is not so objectionable as leaving a stub of the internode. Making the lower cut straight across and the top cut at a sharper angle aids, furthermore, in orienting the top and bottom of the cutting in future handling operations and in planting. Tendrils and small laterals should be removed to facilitate handling and to improve the appearance of the cuttings.

Bundling and Storing.—To facilitate handling, the cuttings are put in bundles of 100 or 200 each, with the basal ends even, and tied with two wires, one near the top and the other near the bottom. Each bundle should carry a durable label tied where it is not liable to be accidentally torn off. The label should show the name of the variety, the number of cuttings, the place where they were obtained, or any other information needed for definite identification. Wooden tree labels, painted white on one side and attached with copper wire, are excellent. A good system is to wire the label to a cutting on the outside of the bundle in such a position that it can be slipped under the top tie wire of the bundle.

If the cuttings are to be held for a long period (a month or more) before planting, they should be stored in a cool place, neither too wet nor too dry. Burying in moderately moist (not wet) sand in a cool cellar is ideal. If a cellar is unavailable, they may be buried in a pile of moderately moist sand in a shed or in a pile of sand out in the open. In the latter case, the pile should be covered with boards, straw, or other material, to prevent the sand from drying out or from getting too wet or too warm. This last precaution is particularly necessary if the planting must be delayed until late spring, for otherwise the buds may start growth, which greatly increases the care and cost of planting and may considerably reduce the stand obtained.

If the cuttings are to be held only for a few weeks, they may be buried in the soil in any well-drained location and completely covered with soil to a depth of 3 or 4 inches.

Planting.—In a well-drained soil, particularly in the warmer regions of California, the best time to plant is immediately after the cuttings are made or as soon thereafter as possible. Particularly in the hotter and drier regions, the best possible place to hold cuttings through the winter is in the nursery row in a well-drained soil. Much experimental work has been done on the stimulation of cuttings with chemical reagents, callusing, and heat before planting; but in nearly every case, results equal or superior to the best obtained by artificial stimulation have been

obtained by planting the cuttings in the nursery immediately after making them. For varieties that are rooted with considerable difficulty, such as the Berlandieri hybrids which are used as grafting stocks, making the cuttings very soon after the leaves fall and planting them immediately has given the best results.

In the cooler regions where much rain falls during the winter, cuttings should not be planted in the autumn in any except very well-drained sandy soil. In heavy, poorly drained soil that remains waterlogged for weeks, poor aeration may cause considerable losses from rotting.

Cuttings should be planted in straight rows to facilitate care of the nursery and digging the rootings. The depth of planting should vary slightly with the texture of the soil, being deeper in light sandy soils and shallower in heavy ones. Usually this variation is accommodated by making the cuttings to be planted in light soil a little longer than those to be planted in heavy soil. They are then planted with the uppermost bud from 2 to 4 inches above the general ground level. At the time of planting, the tops of the cuttings are completely covered with a ridge of loose soil. When wet by subsequent rains or irrigation the soil settles, leaving the top bud above the surface.

The method of planting varies with the equipment available, the condition of the soil, and the preferences of individual growers. If the soil is moderately and uniformly moist, an excellent plan is to run the standard of a subsoiler, without the shoe, about 18 inches deep where the row is to be. The cuttings can then be easily pushed in to the proper depth, and the tops covered over with a ridge of loose soil. This method of planting will not work satisfactorily if the soil is too dry. Within a few days after planting, a thorough irrigation must be given to settle the soil around the cuttings. Some growers irrigate before covering the tops of the cuttings. The main objection to this practice lies in the difficulty of controlling the flow of water.

The other common method of planting—preferable to that described above when irrigation water is not available soon after planting—is as follows: With a turning plow a very deep furrow, at least 10 inches, is drawn with the land side of the plow in the position where the row is to be. Then the bottom of this furrow is loosened 2 or 3 inches deeper by going through it with a second, smaller plow, a light subsoiler, or other suitable implement. The loose soil thus formed in the bottom of the furrow is not removed. The cuttings are stuck into the loose soil so that they rest against the vertical side of the furrow. The soil around the base of the cuttings is firmly packed by tramping. Then most of the soil thrown

out of the furrow is turned back into it. When the furrow is about three-fourths filled, the soil should again be packed firmly around the cuttings by tramping or settled by irrigation. The ridge of loose soil completely covering the cuttings can then be finished by hand labor with a shovel and a garden rake. If the soil is in ideal condition, the land side of the furrow will stand up, and the cuttings may be planted without a planting line or board. If the soil is too loose or too dry, the land side of the furrow breaks down; and a taut line or a board (fig. 9) must be used to obtain a straight row. Irrigation should follow within a few weeks after planting unless the soil has been wet by rain in the meantime.

If a small lot of cuttings is to be planted by hand labor, the best way is to shovel out a trench about 10 or 11 inches deep; stand the cuttings against one side of this trench; refill the trench, packing the soil very firmly around the lower half of the cuttings; and finally cover the cuttings completely with a ridge of loose soil. The cuttings must of course be placed in the soil with the top end up. Any put in upside down will not grow.

In a fertile soil where the nursery can be irrigated, the cuttings may be spaced as closely as 2 inches in the row with the rows 4 feet apart. In a less fertile soil, particularly if they cannot be well irrigated, wider spacing in the row will produce larger and better rootings.

LAYERS

Layering as a means of propagating vines is recommended under two conditions: (1) as a means of multiplying vines of varieties whose cuttings can be rooted only with great difficulty, and (2) to replace occasional missing vines in an established vineyard.

Layering for Varieties Difficult to Propagate by Rooting Cuttings.—Some varieties, whose cuttings strike root poorly, can be easily propagated by simple layers, trench layers, and mound layers. The simple layer is a cane buried in moist soil for a part of its length with the tip end exposed. The cane is usually shortened so that only 1 or 2 buds project aboveground. To make the trench layers, trenches 8 to 10 inches deep are dug in early spring, radiating from the parent vine. A cane is laid down in each trench, held in place by pegs, and covered with 2 or 3 inches of soil. As the shoots arising from the buds of the buried cane grow, soil is filled in around them until the trench is full. The cane strikes root at each node; and the following winter, rooted plants are obtained by digging up the cane and cutting it into the proper sections. Mound layers are made by completely covering the heads of low-headed vines with soil during the growing season, leaving the tips of the growing

shoots exposed. Each shoot strikes root near its base and the following winter can be removed from the parent stock as a rooted vine. These methods are particularly useful in propagating varieties of the rotundifolia group, such as Scuppernong, Flowers, Eden, and James.

Replacing Missing Vines.—By far the most important use made of layers in the vineyards of California is to replace occasional missing vines in established vineyards where competition with older vines makes

Fig. 2.—A missing vine in a cordon-pruned Emperor vineyard replaced by means of a layer from an adjacent vine. A wire has been placed around the layered cane at *W* to hasten the development of the new vine, which is three years old and ready to be cut from the parent vine.

it difficult to fill in the vacancies by planting rootings. For this purpose the simple type of layer is used. A long, vigorous cane from a vine adjacent in the row to a missing vine is bent down into a hole or trench about 10 inches deep. The tip end projecting after the hole is filled should be exactly in position to replace the missing vine. It is usually shortened to one or two buds above the ground. The layering can be done during the winter whenever the soil can be worked. A wire should be placed around the cane between the parent vine and the buried portion of the cane and twisted until it is snug. As the cane grows, the wire becomes tight and acts as a partial girdle, increasing the rate of development of the new vine.

The only care needed by these layers during the growing season is to prevent all growth on the layered cane except the single shoot reserved

for the trunk of the new vine and to tie up this shoot carefully to give the new vine the desired form. All buds that start on the cane between the parent vine and the ground should be rubbed off.

The new vine produced from a layer should be allowed to bear little or no fruit the first year and only a limited crop the second. The vine, thus enabled to devote all its energies to growth of stem and root, will be able by the third year to compete successfully with its older neighbors. It is then ready to be cut from the parent vine (fig. 2).

GRAFTS

Nature of a Grafted Plant.—Any grafted plant consists of three essential parts: the stock, the scion, and the union. The stock consists of the root, the underground stem, and sometimes a part of the aboveground stem and branches. The scion consists of all the rest and always includes the leaf-bearing and fruit-bearing parts. The union is the place or region where the stock and scion are joined.

Purpose of Grafting.—Vines are usually grafted for one of four reasons: (1) to obtain vines of the desired fruiting variety on roots resistant to phylloxera or nematode; (2) to correct mixed varieties in an established vineyard; (3) to change the variety in an established vineyard; (4) to increase rapidly the stock supply of new or rare varieties.

Most varieties that produce fruit of desirable character are susceptible to the attacks of phylloxera (grape-root louse) and nematode (root knot or eelworm). The only known practical means of growing susceptible varieties in soils badly infested with either is to graft them on immune or resistant rootstocks. The methods of bench grafting and budding described in this circular have been developed particularly for this use.

Methods of field grafting suitable to correcting mixed varieties, changing the variety in an entire vineyard, and rapidly increasing the stock of new varieties are briefly described in the following pages. More complete information can be found in Circular 115.[4] Before undertaking to change the variety in an entire vineyard by grafting, one must duly consider the cost of grafting and training the new vines and the probable profitableness of the new as compared with the existing variety. Usually where a change of variety is desired, it is better to uproot the old vineyard and replant with the desired variety than to try grafting.

Requirements for Successful Grafting.—The most important factors governing success in grafting vines are compatibility or affinity between stock and scion; favorable conditions of moisture, temperature, and

[4] Bioletti, Frederic T. Grafting vinifera vineyards. California Agr. Exp. Sta. Cir. 115:1–8. Revised 1931 by H. E. Jacob.

aeration; contact or close proximity of the cambium layers of the stock and scion at one or more points; mechanical rigidity to maintain the relative position of stock and scion until the union is formed; youth of scion and stock, particularly the scion; and degree of vegetative activity of the stock.

Compatibility refers to the capabilities of the stock and scion existing together and involves structural and chemical similarity. Usually varieties of the same botanical species graft readily on one another. Thus almost all vinifera grape varieties—Muscat, Thompson Seedless, Tokay, Carignane, Zinfandel, and the like—are easily intergrafted. The results of grafting one species on another of the same genus are more uncertain. Occasionally such grafts are nearly perfect, but occasionally they are impossible. An example of a nearly perfect interspecific graft is Carignane (*Vitis vinifera*) on St. George (*Vitis rupestris*). An example of a more difficult interspecific combination of grapes is Muscat (*Vitis vinifera*) on Scuppernong (*Vitis rotundifolia*). Compatibility is usually lacking between different genera of the same family. A few notable exceptions occur—for example certain pear varieties (*Pyrus communis*) on quince (*Cydonia oblonga*). Rarely can a plant belonging to one botanical family be grafted on a member of a different family. Some effects of partial or incomplete compatibility are failure to unite, imperfect or structurally weak unions, overgrowth of the stock or scion, decrease in longevity, decrease in vigor, increase or decrease of fruitfulness, and changes in the quality of the fruit.

Favorable conditions of temperature, moisture, and aeration are required for callus formation, the first step in the growing together of the tissues. It takes place best in an atmosphere nearly saturated with moisture at a temperature of 75° to 85° F and with a good supply of air. Grape grafts usually should not be waxed to prevent drying out of the tissues, as is done in grafting most other plants, because the wax so excludes the oxygen of the air that many of the grafts fail. Drying out is prevented and aeration provided by covering the graft with some moist porous material—soil, sand, moss, or sawdust.

Union between stock and scion is made primarily by outgrowths of the respective cambium layers that bridge the gap between the stock and the scion. The narrower the gap to be bridged, the more rapid the union. The process is facilitated, therefore, by the closest proximity and the most complete coincidence possible of the respective cambiums. Not only must the cambiums of the stock and the scion approach each other very closely in at least one point, but this proximity must be maintained until stock and scion are firmly grown together. If the union, once

formed, is broken by movement of the scion on the stock, the bridging of the gap must start all over again. Consequently mechanical rigidity is as essential as a good fit. After the gap is bridged, differentiation of the growing tissue occurs to form the xylem (wood) and phloem (bark) tissues which function in the conduction of water and nutrient substances.

Generally the younger the parts to be grafted together the more successful the grafting, provided, of course, the requirements of good fit, mechanical rigidity, moisture, temperature, and aeration can be met and maintained. Herbaceous (green) grafting of vines is not at all difficult, but proper conditions for union are more difficult to maintain with soft green tissues than with mature tissues. Young vines are easier to graft than old vines. Seldom, if ever, should older than current season's growth be used for scions.

Best results with dormant grafting are obtained by delaying the work until the stock starts growth, or near that time. The scions should be kept dormant by holding them in a cool place. Summer grafting or budding is most successful when the stocks are growing vigorously.

Influence of Grafting on the Characters of Stock and Scion.—Grafting may alter the nutrition of the plant, thus affecting any characters of either stock or scion susceptible to influence by changes in nutrition. Grafted vines may be either more or less vigorous, more or less fruitful, produce larger or smaller berries which may be darker or lighter in color, and ripen their fruit earlier or later than ungrafted vines of the same variety. These are influences of the same nature as those caused by variations in soil, climatic, and cultural conditions. No changes in varietal characteristics can be produced by grafting. A Muscat grape retains its Muscat flavor no matter on what stock it is grown, and similarly the St. George retains its resistance to the phylloxera regardless of the scion variety used on it. There is no exchange or intermingling of characters between stock and scion. Since, however, the relatively minor changes in vigor, fruitfullness, and character of the fruit that do occur with grafting may seriously affect the profitableness of a vineyard of grafted vines, the stock selected should be well suited to the particular variety under the given conditions.

BENCH-GRAFTING

In the past, bench grafting has been the most common method of producing grafted vines of the desired fruiting varieties on roots resistant to phylloxera or nematode. The work is carried on in a well-lighted place, usually indoors, during the late winter and early spring. The newly

made grafts are callused in sand or a hot room and grown for a year or longer in the nursery before being planted in the vineyard. Single-bud scions of the desired fruiting variety are grafted on either unrooted cuttings or one-year-old rootings of the desired stock variety. Bench-grafting is well suited to commercial nurserymen but not to individual vineyardists, who usually lack the necessary equipment and skill for successful operation.

The wood for the scions and unrooted stock cuttings should be selected according to the directions given for cuttings to be planted in the nursery. The canes for scions and those for stock cuttings are often made up in lengths of 30 inches or more. Then when the grafting is done the long pieces are cut into the desired lengths—about 11 inches for the stocks and single-bud pieces for the scions.

Rootstock and scion material for bench grafting may be stored in sand as are cuttings for nursery planting. If so stored, they must be washed free of sand before use. To avoid this troublesome washing and to insure freedom from anything apt to damage the cutting edge of the grafting knives, cuttings for bench grafting are often stored in some other medium. Rice straw, free from water grass and tules, or clean rice hulls are excellent. Either the straw or the hulls should be soaked in a ½ per cent solution of copper sulfate before being used. The copper sulfate retards the development of molds, yeasts, and bacteria. The cuttings may be dipped in lime-sulfur solution before being stored in rice straw or hulls. The lime-sulfur solution is made by diluting 1 gallon of the concentrated liquid with 12 or 15 gallons of water. It effectively prevents mold growth on the cuttings.

Preparing the Stocks and Scions.—Just before grafting, the stock and scion materials are removed from the storage place, are washed clean, and, if at all dry, are soaked for 24 hours in water. Then the stocks are cut to the desired length (about 11 inches) with the basal cut immediately below the lowest node and the upper cut at a distance of 1 inch or more above a node. They are then disbudded (all buds completely removed) with a knife or small pruning shears, to prevent the growth of stock suckers in the nursery and later in the vineyard. The disbudded stock cuttings are then graded according to the diameter *at the top* where the graft is to be made. The grading is usually done by eye into 3 or 4 sizes; but if it is done accurately with a slot or notch grader, as many as six or seven sizes may be obtained. Accuracy in grading greatly facilitates and speeds up the work of grafting.

The scions are cut to a single eye with not over ½ inch of internode above and from 1½ to 2 inches of internode below the bud. They are

graded according to the diameter *at the bottom*, into the same series of grades used for the stocks. Economical and successful bench grafting of cuttings requires that stocks and scions be of similar diameter.

The actual grafting is usually done by hand, either the short whip or the long whip graft being used, according to the method of callusing

Fig. 3.—The short-whip graft: *A*, the sloping cuts made on the stock and the scion; *B*, the tongues cut and opened out; *C*, the completed graft ready for callusing.

followed. The short whip is made most rapidly and easily. It should be used, however, only where the grafts are hot-room callused, because they are easily broken and must be carefully packed in some supporting medium until they grow together. For sand-callusing, the long whip, tied to secure additional strength, is better.

Short Whip Grafting.—The short whip graft is made as shown in figure 3. Stocks and scions are cut exactly alike except that the cuts are

made on the upper end of the stock cutting and on the lower end of the scion. Usually three or more cuts are used to shape each. The first cut, made at an angle of about 45°, is seldom straight and true enough for the graft. The second cut removes a thin slice which trues and straightens the first cut. This cut must be made with a single quick, sliding motion of the knife; and, if the surface of the cut is not satisfactory, a completely new one should be made, again removing a thin but complete shaving. There must be no paring of the cut, as this will make an irregular or wavy surface that prevents a good fit between the parts. The tongue is made with a slow, sliding motion of the knife. The cut is commenced slightly more than one-fourth of the distance in from the sharp point of the bevel and continues in a *straight* plane downward, bisecting the angle of the bevel cut and the grain of the wood, until the tongue is slightly less than one-half the length of the cut surface. The tongue must be cut, not split, and should be about half as thick as it would be if the knife were allowed to follow the grain of the wood. The knife is slowly withdrawn with an oblique motion to avoid breaking the tongue; and just before it is free of the cut it is slowly and carefully bent over to open out the tongue. This technique greatly facilitates the placing together of stock and scion (fig. 3, *B*).

The stock and scion are now placed together; and, if everything has been done properly, no cut surface will be visible, and neither stock nor scion will project over the cut surface of the other (fig. 3, *C*). It is much better that the points should not quite reach the bottom of the cut surface than that they overlap, as the unions will be more complete and the scions less apt to throw out roots. If the points do overlap, the overlapping portion should be cut off. If the fit is not good and the graft not firm, it should be completely remade.

A skillful worker, following this method, will make grafts that will hold together very firmly; and tying is unnecessary if the grafts are hot-room callused. Good work cannot be done, however, with a poor knife.[5]

Long Whip Grafting.—The cuts for the long whip graft are made as are the corresponding cuts for the short whip except that the cut surface forms an angle of 15° to 25° with the side of the stock (or scion) instead of the 45° used in making the short whip (fig. 4). Thus the cut surface

[5] The blade of the grafting knife should be of high-quality cutlery or razor steel, properly hardened, and should have a straight edge about 2¼ or 2½ inches long. It should be ground straight on one side—the left side (facing the edge), for a right-handed worker, and the right side for a left-handed worker—and beveled on the other side. The cutting edge must be very keen (razor sharp) and will work best if ground to an angle of about 17°. If it is too thin, the sharp edge cannot be maintained. If it is too thick, difficulty will be encountered in making straight cuts, and the tongues will break as they are cut.

for the long whip is about 2½ to 4 times the diameter of the cutting, whereas with the short whip it is about 1½ times the diameter.

After the scion and stock are put together, the long whip graft is tied with raffia, string, or grafting rubber until they unite by the growth of their own tissues; the less material used the better. Since air is neces-

Fig. 4.—The long-whip graft: *A*, the sloping cuts made on the stock and the scion; *B*, the tongues cut and opened out; *C*, the completed graft, tied and ready for callusing.

sary for the formation of healing tissue, no clay, wax, tinfoil, or other air-excluding material should be used to cover the union. The tying material is passed 2 or 3 times around the point of the scion to hold the latter down firmly; and then with 1, 2, or 3 wide spirals it is carried to the point of the stock, which is fastened firmly with 2 or 3 more turns, the end of the string being passed under the last turn.

Untreated raffia may be used for late grafts; but for early grafts which are to be callused in sand, it is best to bluestone the raffia in order to prevent rotting before the grafts are planted. The bundles of raffia are steeped in a 3 per cent solution of bluestone (copper sulfate) for a few hours and then hung up to dry. Before using, the raffia should be

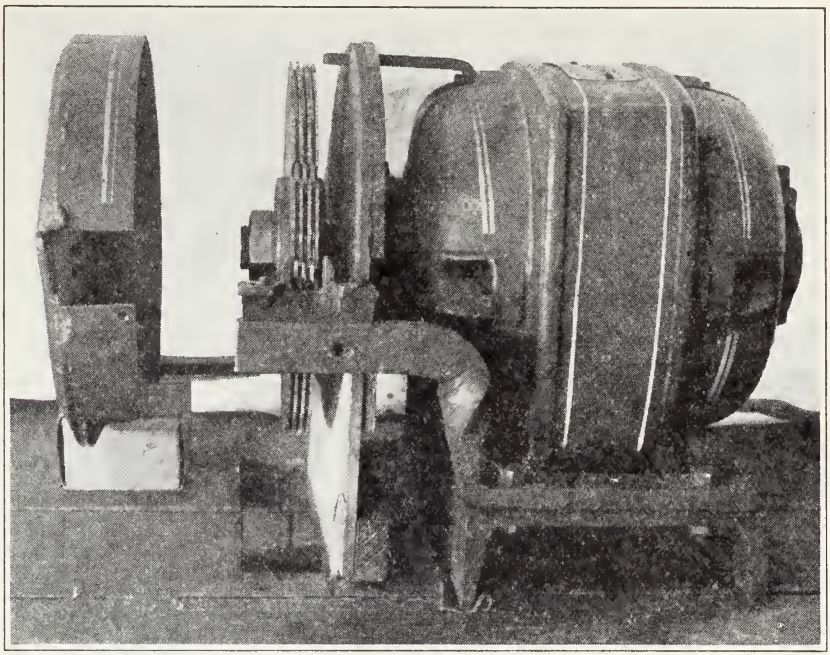


Fig. 5.—The multiple-saw grafting machine. The safety cover at the left has been removed to show construction details.

washed quickly in a stream of water to remove the bluestone crystallized on the outside, which might injure the graft if not removed.

Some grafters prefer waxed string, strong enough to hold the graft but thin enough to be broken by hand. No. 18 knitting cotton is a good size. The balls are soaked in melted grafting wax for several hours. A good wax for this purpose is made by melting together one part of tallow, two parts of beeswax, and three parts of rosin.

If used sparingly, grafting rubber is very satisfactory. If, however, the entire unions are closely wrapped so that the air is excluded, many or most of the grafts will fail. The rubber must be cut and removed the first time the scion roots are cut in the nursery.

Machine-Grafting.—Where skilled hand grafters cannot be employed, bench grafts are occasionally made by machines. Although fairly successful, such machines usually do not do the work so perfectly nor so

rapidly as the skilled hand workers. Of course, less skill is required to operate the machines than to graft by hand, and unskilled workmen can graft faster with the machines than by hand.

A very successful machine utilizing the basic ideas contained in an Austrian patent issued to Albert Hengel[6] of Limberg, Austria, has been constructed and used in experiments at the University Farm at Davis (fig. 5). It consists essentially of four 8-inch, planer-type, circular saws each $\frac{1}{16}$ inch thick, mounted in a gang head on the shaft of a ½ hp., 3,600 r.p.m. ball-bearing electric motor. The saws are separated by spacer disks of the same thickness as the cutting edges. The spacer disks also gauge the depth of the cuts. The stocks and scions are pushed endwise (radially) against the saws. By means of spacer disks 7½ inches in diameter, the depth of the cuts is limited to ¼ inch. Thus a slip-joint consisting of one, two, three, or four tenons, according to the diameter of the stock (or scion) and the corresponding indentures, is formed on the upper end of the stock and on the lower end of the scion. The table or guide is so constructed and adjusted that when the stock is cut against the right-hand guide and the scion against the left-hand guide, or vice versa, a good fit between the two is obtained, provided they are of the same size and the end of each has been cut square across before the slip-joint is sawed on the machine (fig. 6).

With this machine three reasonably fast men can make between 700 and 1,000 grafts in an hour. Good, straight, hard wood, carefully graded according to size, is necessary for the fastest work. In a number of carefully conducted tests, the grafts made with this machine were comparable to short-whip grafts made by hand by a skilled workman. Over several years, the average percentage of machine-made grafts that grew into No. 1 rooted one-year-old grafted vines has been slightly less than from skilled hand grafts because in hand work all apparently defective stocks and scions are discarded, whereas with the more rapid machine operation some of the defective material escapes detection.

Bench-grafting Rootings.—If one-year-old rootings are to be bench-grafted, they must first be washed clean. Then the rootings are shortened to a uniform length of about 12 inches and completely disbudded; the

[6] The Hengel machine made use of 4-inch saws with large teeth. [Mader, J. Die Lamellenveredlung (System Hengel) und deren Erfolge in Oesterreich und im deutschen Reiche. Wein und Rebe 8:431–436. Feb. 1927.] The saws were mounted on a shaft which was belted to a motor of approximately ¼ horse power. Because of the low peripheral speed and the large teeth of the saws, the cuts were ragged; and in European nurseries the machine was considered impractical. The experimental machine constructed at the University Farm has, however, done very satisfactory work. The status of the Hengel patent in the United States would have to be determined before the machine could be safely manufactured and used for commercial purposes.

roots are cut back to very short stubs, not more than 1 inch in length. One-bud scions are grafted on them by the long whip method. They are usually callused in sand and replanted for one year in the nursery before being placed in the vineyard.

As certain excellent rootstocks, particularly the Dogridge and some of the Berlandieri hybrids, root poorly from cuttings, bench grafts of

A B C

Fig. 6.—Steps in making the multiple-saw graft using the machine illustrated in figure 5: *A*, the ends of the stock and scion squared; *B*, the tenons and corresponding indentures cut on the machine; *C*, the completed graft ready for callusing.

their unrooted stock cuttings give very low nursery yields. It is sometimes more economical to root the cuttings first and then do the grafting. Also, when stock cuttings are made, there is always much wood too small in diameter to be bench-grafted, but perfectly sound and well matured. If this is planted in the nursery, after one year it is excellent stock material. Field budding has, however, largely superseded the practice of bench-grafting rootings.

Callusing.—When the grafts are made, the stocks and scions are nearly or completely dormant; but when placed in the proper favorable conditions, they begin growth processes which bring about the rooting of the stock, the sprouting of the scion, and the uniting of one with the other. These favorable conditions do not usually exist in the nursery at the time of grafting. If, therefore, the grafts are planted out directly, many will dry or be injured by cold or excess moisture before they can begin active growth. For this reason, the newly made grafts should always be placed where moisture, temperature, and aeration can be controlled until the unions are made.

Sand-Callusing.—The long whip grafts are usually callused in moist sand. First, they are tied in bundles of ten each for convenience and economy in handling. Raffia treated with bluestone is excellent for tying. Two ties, one near the bottom and the other near the top, are best, though often a single spiral tie covering the middle one-fourth of the bundle is used.

Fine sand free from pebbles, clay, and organic matter is best. Fine, clean, building sand is ideal. It must be sufficiently moist to support plant growth and not too wet to work easily between the bundles of grafts. A good moisture content is obtained by mixing together equal quantities of dry sand and sand that has been recently wet and allowed to drain.

The callusing bed may be a pile of sand in an open shed or out of doors on the south side of a building. The shed, if used, should be in a warm location. A callusing bed in the open must have a glass, canvas, board, or other type of cover so that it can be protected during rainy or cold weather and opened during dry, warm weather.

The bundles of grafts may be placed in the sand in a nearly vertical position, one row at a time, scions up, and sand worked in between the bundles. A layer of sand 2 or 3 inches deep is laid on the bottom of the bed before the grafts are placed in, and the tops of the grafts are covered with a uniform layer of sand 3 or 4 inches deep. All the unions should be at the same level. The top of the sand must be slightly moistened every day or two to replace the water lost by surface evaporation. Care must be used to wet only the sand that has dried out and to cover the bed during rainy weather and on cold nights.

In another common method of sand callusing, a level layer of sand 2 or 3 inches deep is first laid down on the floor of an open shed. Then a single layer of bundles of grafts is placed horizontally on the sand. The grafts are covered with another layer of sand, and then another layer of grafts is added, which is followed by alternate layers of sand and

grafts until the stratified pile reaches a height (or depth) of 3 or 4 feet. The grafts at the bottom callus more slowly than those near the top because of the lower temperature. Since several days may be spent in building the pile, however, and another day or two in tearing it down when the grafts are planted, grafts in the bottom are necessarily in the sand longer than those near the top.

Unless one is thoroughly experienced in the handling of grape bench grafts, the vertical placing of the grafts is preferable to horizontal stratification.

If the temperature of the sand is about 75° F, the unions will callus over and the buds and roots begin to grow in 3 or 4 weeks. Higher temperatures will decrease and lower temperatures increase the time required. Temperatures above 85° cause the formation of profuse, soft callus tissue which may die or be severely injured by unfavorable conditions during or after planting in the nursery. Below 70°, callus formation is very slow; and below 60° it practically ceases. The grafts should be planted in the nursery as soon as the unions are well callused and before the shoots and roots have made excessive growth.

Hot-Room Callusing.—For hot-room callusing the grafts are packed into boxes, moss or sawdust mixed with charcoal being used as a packing medium. The boxes may be of any size, except for the height, which should be from 8 to 10 inches more than the length of the grafts—about 24 inches under California conditions. A convenient size is 16 inches wide and 19½ inches long (inside), which will hold 500 grafts of average size. When the boxes are made, spaces of ⅛ to 3/16 inch should be left between the individual boards to allow for drainage. It is also well to perforate the bottom with several rows of small holes. To facilitate packing and unpacking, one side of the box should be hinged.

The best inexpensive packing material is a mixture of 3 parts coarse sawdust and 1 part "fine chick" charcoal. Since the water-holding capacity of this material is not very great, the boxes should be lined on the sides and bottom with a 1-inch layer of sphagnum moss. Besides holding water the moss prevents the sawdust-charcoal mixture from sifting out through the cracks or holes in the boxes.

For filling, a box is laid on its unhinged side, and the hinged side is propped open (fig. 7). A layer of wet moss about an inch deep is spread over the side that is down and up several inches on the vertical sides and bottom. Then a light layer of wet sawdust and charcoal is sprinkled over the moss, and a layer of grafts laid horizontally on the sawdust-charcoal layer with the ends of the stocks about 2 inches from the bottom of the box and with the scions all at exactly the same distance from the normal

Fig. 7.—Callusing box showing method of filling. (From Cir. 288.)

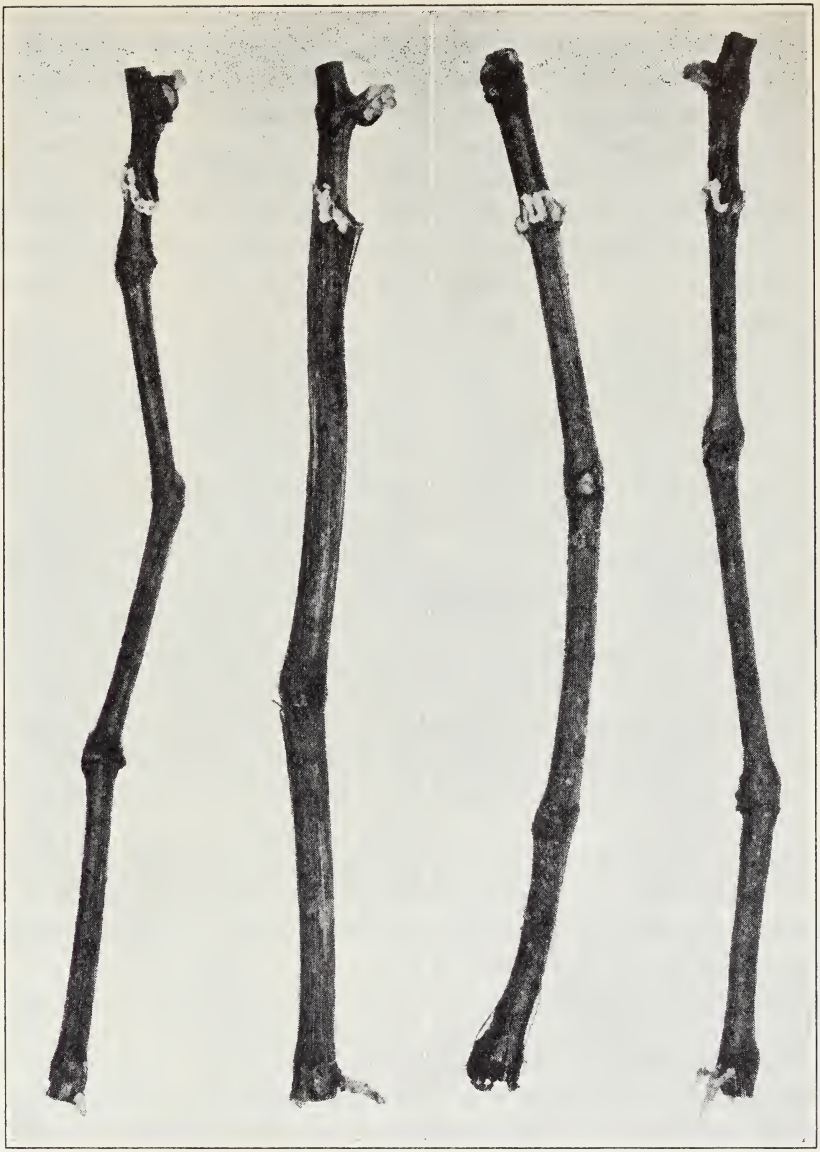
top of the box. It is convenient to fit a loose board temporarily into the box so that, during filling, the tops of the scions can be butted against the board. More of the sawdust-charcoal mixture is added to cover the grafts and is followed in turn by another layer of grafts. The box is filled to within an inch of the open side with alternate layers of grafts and the sawdust-charcoal mixture, the moss being built up on the sides and bottom as necessary. After a layer of moss has been put on top (the open side of the box), the hinged side is closed and fastened. When full the box is set upright, and the tops of the scions are covered to a depth of 1½ inches with the sawdust-charcoal mixture. If the callusing is delayed, the filled boxes may be set aside in a cool place for a few days.

Just before placing the boxes containing the grafts in the callusing room, they should be warmed to 75° to 80° F by dipping each box and its contents into warm water to a depth just below the unions. Do not submerge the unions. After removal from the dipping tank, sprinkle the top of the box copiously with warm water (80° F). If the packing material settles appreciably, add more. Then, after the box has been set aside to drain, it is ready to go into the callusing room.

The callusing (hot) room may be any well-ventilated room of convenient size and shape in which the temperature can be held within a range of 75° to 80° F and the moisture conditions within reasonable limits—neither too wet nor too dry. Any heating system that will maintain an even temperature throughout the room may be used. Though a small wood, coal, or oil stove may be used in a small room, hot water, steam, electric, or gas equipment is much superior because of its greater uniformity of heating, safety, and ease of regulation. Thermostatically controlled steam or electric heat is ideal. For economy of fuel (or electric power), the room should be insulated. Windows or ventilators should permit even and adequate ventilation. Light is unnecessary; the direct rays of the sun may cause excessive drying out of the boxes.

The boxes may be placed in 2 or 3 superimposed layers on shelves or trestles separated by adequate alleyways. A space of several inches should be left between the boxes and the walls and between the sides of adjacent boxes. Water draining from the boxes in the upper layers must not fall on boxes underneath.

At a temperature in the boxes of 75° F (from 75° to 80° in the room) the wounds will callus in three or four weeks. Early in the season, when stocks and scions are fully dormant, a few days longer are required for callusing than later, when the processes of growth have already started before the grafting is done or before the boxes are actually placed in the callusing room.



A *B*

Fig. 8.—Callused bench grafts: *A*, handmade short whip; *B*, machine-made.

After the grafts have been in the callusing room 10 days or two weeks, the boxes containing the grafts should be removed and dipped in warm water (75° to 80° F) to aerate the boxes. The boxes should be carefully lowered into the dipping vat so that the water gradually enters and fills

the box nearly to the level of the unions, which it should not reach. The boxes are then removed, allowed to drain, and replaced in the hot room. If—as usually—there is a variation in temperature in different parts of the hot room, boxes taken from the warmer parts should be put back into the cooler places, and those that were in the cooler parts should be put back into the warmer places. This exchange will cause the callusing to develop uniformly. The tops of the callusing boxes should be kept fairly dry; but if the sawdust-charcoal immediately covering the grafts becomes dry, it should be moistened by lightly sprinkling with water of the same temperature as the room.

Hardening.—When the callusing is complete all around the wounds, the boxes are transferred to the hardening room, where the temperature is fairly constant but about 10° F below that of the callusing room.

At this stage the best grafts should show callused unions, indication of root formation, and swelling of the buds (fig. 8). Others will have formed short shoots and short roots; still others will show little or no sign of roots or shoots. At the lower temperature, shoot growth proceeds more slowly, but the unions bridge across with normal conductive tissue which enables the stock and scion to exchange materials. Callus tissue does not do this, and the union is not complete until this conductive tissue forms.

After a week or 10 days at this lower temperature the grafts may be planted in the nursery if weather and soil conditions are good. Otherwise they may be stored for another week in any cool protected place, such as an open shed.

Planting the Grafts.—More care is necessary in planting callused bench grafts than for nursery cuttings. The soil should be warm, moist, and well pulverized. The weather should be mild—not cold, nor very hot, nor windy.

As the callused grafts are unpacked, either from the sand or from the callusing boxes, they are carefully inspected. All suckers from the stocks and all roots from the scions must be broken off or cut very close. Any scion shoots and any stock roots more than an inch long should be cut back to that length. If they are longer, it is practically impossible to save them; and if they are shortened, new ones will start soon after planting. Grafts that are hot-room-callused are best hauled to the nursery in the callusing boxes and unpacked there. The grafts must be kept covered with wet sacks or other suitable material between the time they are removed from the callusing boxes or sand and the time they are planted. In all operations they must be handled very carefully in order to avoid breaking the unions.

In well-prepared sandy soil, free from gravel, good planting can be done with a long, heavy, flat dibble; but it is more usual to plant in trenches. If a dibble is used, the surface of the soil must be made level and smooth by dragging or rolling. The grafts are planted so that the unions are just above the level of the soil. The scions are immediately covered carefully to a depth of 2 or 3 inches with a wide ridge of soil.

A planting distance of 3 inches in the row is sufficient in a fertile sandy loam or loam soil that can be well irrigated. In a poorer soil or where

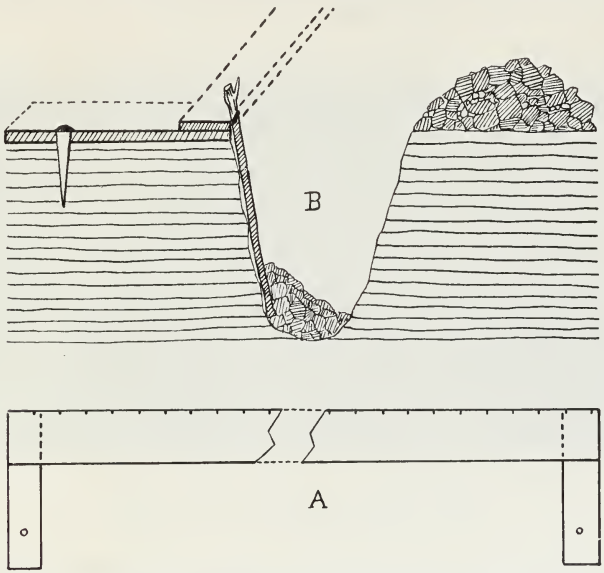


Fig. 9.—*A*, Planting board. *B*, Diagram showing use of planting board with bench grafts. (From Cir. 288).

irrigation water may be scanty or lacking late in the summer, a spacing of 4 or 5 inches in the row will produce larger and better vines. The rows may be spaced as close as 3 feet, but 4 feet makes planting, cultivation, irrigation, and digging easier.

For planting in a trench, a planting board is indispensable. One 16 feet by 4 inches by 1 inch, marked with a saw cut or shallow notch every 3 or 4 inches, according to the spacing desired in the row, and with an 18-inch crosspiece at each end, is convenient. A hole in the end of each crosspiece, through which a small iron bar or a heavy spike can be thrust, easily holds the board in place. The board is laid in position on the edge of a straight trench, made with a plow or by hand and in depth at least equalling the length from the union to the base of the stock. Each graft is placed opposite a saw cut (or notch) with the union just above the guide (fig. 9). The trench is half or two-thirds filled with soil, firmly

packed around the stocks by tramping. It is then filled with loose soil, and the planting board moved to a new position, after which the scions are carefully covered with fine soil to a depth of 2 or 3 inches. The ridge of soil covering the grafts should be broad and regular (fig. 10). A narrow ridge dries out too quickly. An irrigation should follow within a day or two but should not wet the tops of the ridges.

In the coastal valleys of California one need give the grafts little or no further attention for some time except to control weeds and carefully break the crust that forms after rain. In the hot interior valleys the

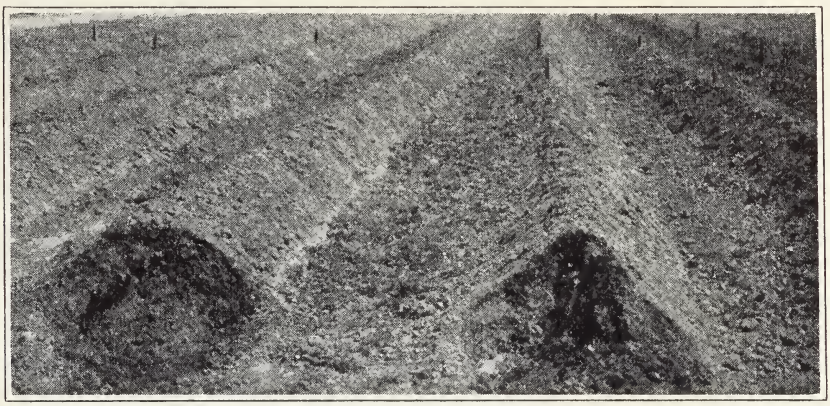


Fig. 10.—A newly planted nursery of bench grafts. The two rows in the foreground have been partially uncovered.

ridges may dry out badly enough to injure the scions and may therefore require one or more additional irrigations before the shoots come through the soil.

Removing Scion Roots, Stock Suckers, and Tying Material.—As soon as the grafts are growing vigorously the unions should be examined, and all roots that have started from the scions should be removed. This will be about the beginning of July in the warmer districts and the end of July in the cooler districts.

The scion roots are useful to the graft for a while in keeping the scion alive and allowing the union to become perfected; hence they should not be removed too soon. The stocks usually start more slowly than the scions because they are deeper in the soil where the temperature is lower. The scion roots, however, take the nourishment elaborated by the scion leaves, thus starving the stock roots. If the scion roots are removed too late, the stock roots may be unable to supply sufficient water to support the scion growth, and the graft may die.

At the same time the scion roots are removed, the tying material

(raffia, string, or rubber), if any has been used, should be cut and removed on all the grafts where it has not rotted. With rubber, waxed string, or bluestoned raffia, this operation is very essential; otherwise the growth of the union will be constricted.

Stocks properly disbudded before grafting will produce very few suckers. Those that do grow should be removed as soon as they show above the ground, and any found when the scion roots are removed should be carefully broken out. To perform these several operations it is necessary to dig down beside the grafts to below the unions. The soil should be replaced around the grafts immediately after these operations, and irrigation should follow as soon as possible.

The grafts should be examined again about a month later, and any new scion roots or stock suckers should be removed. After this second removal of scion roots, the soil need not be replaced about the scions.

BUDDING

Summer-budding is becoming increasingly popular in California as a means of establishing vineyards on resistant stock. Rootings of the desired rootstock variety are planted in the vineyard during the winter or early spring. Preferably they should be planted in a slightly inclined position, with the tops to the south or west and with an inch or two of the original cutting above the general soil level. Such planting facilitates the budding operations. If the rootings make good growth and are still growing vigorously in early August, they may be budded the same season that they are planted. If they make only a weak growth, or if lack of soil moisture or some other difficulty has checked growth by early August, it is better to defer the budding until the following summer.

The proper time to start the budding is as early as good buds of the desired fruiting variety can be secured—probably in early August in the cooler regions and late August or early September in the warmer regions. The bark of the wood from which buds are taken should be light brown. Buds from green canes or the green parts of canes do not give good results. As soon as the canes (bud sticks) are taken from the parent vine, the leaves are removed by cutting the petiole or leaf stalk near its base. The bud sticks must then be kept fresh until used by wrapping them in moist burlap, moist paper, or other suitable material.

A special form of chip bud, sometimes called the modified "yema graft," has given best results and is most commonly used (fig. 11). To remove a bud from the cane, two cuts are necessary. The first cut is made deep into the bud stick, beginning about ¼ inch below the bud and sloping downward at an angle of about 45°. The second cut is started about

⅝ or ¾ inch above the bud; and the knife travels in a nearly straight plane behind the bud and ends at the surface of the first cut, removing a wedge-shaped piece ⅛ to 3/16 inch thick at the lower end and about 1 inch long (fig. 11, *A*). The wood in this chip is not removed from the bud.

A notch into which the bud will fit well is made in the stock at or just above the general soil level, preferably on the north or east side of the

Fig. 11.—Steps in budding vines: *A*, the bud removed from the bud stick; *B*, notch made in the stock to receive the bud; *C*, the bud in place; *D*, finished and tied, ready to be covered with moist soil.

vine (fig. 11, *B*). The angle made by the two cut surfaces of the notch in the stock should be slightly more acute than the angle formed by the cut surfaces of the bud piece. This technique insures intimate contact between the lower end of the bud piece and the corresponding cut surface of the stock.

After being fitted into the notch of the stock, the bud must be securely tied with raffia, string, or preferably budding rubber (fig. 11, *D*). First several tight wraps are made near the top of the bud chip; then succeeding wraps are spiralled downward fairly close together, finishing with several secure, close wraps below the bud to hold the lip of the stock that projects over the lower end of the bud chip firmly in contact

with the latter. Immediately after tying, the bud is covered over with 2 or 3 inches of moist, well-pulverized soil. Before this moist soil has a chance to dry out, it in turn should be covered with 4 to 8 inches of well-pulverized soil. If the vineyard is irrigated and the soil around the buds not liable to dry out, a total covering 5 or 6 inches deep is sufficient. If the vineyard is unirrigated and dry soil must be used to complete the covering, then the buds should be covered to a total depth of 8 or 10 inches.

Unless the vines are growing vigorously at the time of budding and the soil is sufficiently moist to insure a continuation of this growth until

Fig. 12.—The growth on June 20 from four different buds put in the previous summer, illustrating the variability in the time of starting.

the bud "takes," one-fourth to one-half of the tops of the vine should be cut off. The tops should not be reduced by more than one-half.

The bud calluses in; that is, it grows fast to the stock in 2 to 4 weeks. In the hotter regions, if the work is done very early in August, the bud may actually start growth very soon. Usually, however, it remains dormant until the following spring. The first winter after the budding, the tops of the vines should be pruned back to one or two buds. Never should they be cut back closer than 1 inch above the scion bud; otherwise the wood may dry out down to the bud, and the bud will not grow. At this time the vines should be staked or trellised. As soon as the buds start to swell in the spring, they are uncovered and examined. Any vines with defective buds may be regrafted at this time by the long whip or other

suitable method. All good buds should again be covered with 2 or 3 inches of loose soil to protect them from frost and to keep them moist.

The buds will probably start somewhat irregularly. Figure 12 shows the growth from buds on four different vines in the same vineyard. The photographs were taken on June 20 of the year following the budding. Some will start almost as soon as the buds on the stocks and will grow vigorously. To slow this vigorous growth and avoid wind damage, a few shoots may be allowed to grow from the stock. All the stock shoots should be removed from vines whose scion buds are slow in starting. The only purpose in allowing any stock shoots to grow is to check the rapid growth of the scion shoots and thus avoid having them broken off by the wind. When the scion shoots are 8 to 10 inches long they should be tied to the stake. At this time the tying material around the bud should be cut and removed if it has not already rotted away. The training thereafter is identical with that of any other young vines. As soon as the scion shoots are safe from wind damage, all stock shoots that have been left previously should be completely removed; and any others that start should be taken off immediately.

Sometimes wood veneer or paper tree protectors are placed around the budded vines in the spring when the buds are examined. These have the advantage of causing the shoots from the buds to grow upright through the protectors rather than horizontally. This facilitates training and almost eliminates breakage by wind. Although tree protectors for this purpose seem to have considerable merit, they have not been used extensively enough to prove that they are worth their cost plus the labor of putting them around the vines.

FIELD-GRAFTING ESTABLISHED VINES

To regraft budded vines whose buds have failed to grow, or to correct plantings of mixed varieties, or to change the variety in an entire vineyard, whip, cleft, or groove (kerf or notch) grafts are commonly employed. The graft is made just aboveground on resistant rootstocks but underground when one fruiting variety is grafted on another to change the variety. In either case the graft is completely covered with soil. No wax or other covering except soil is used.

For vines less than ¾ inch in diameter, the long whip graft described under "Bench Grafting" is best. Scions having two buds are used and are carefully covered completely with a wide mound of moist, well-pulverized soil. If scions as large in diameter as the stocks cannot be obtained, the scions and stocks should be cut so as to fit as perfectly as possible on one side.

Vines from ¾ inch to 1½ inches in diameter are cleft-grafted most easily. After the scion is inserted the stock should be securely tied with raffia, grafting rubber, or string in order to hold the scion firmly in place until the union is formed. Vines larger than 1½ inches in diameter may be cleft- or groove-grafted and need not be tied. The best time to graft is just as the vines in the vineyard are starting growth in the spring.

SOILS AND LOCATION OF THE NURSERY

A fertile, well-drained soil that works easily and is free from noxious weeds is best for the vine nursery, particularly for bench grafts. Good rootings can be grown from cuttings planted in soils ranging all the way from sand to clay loams provided they are well drained and properly cared for. Poorly drained soils should always be avoided. Noxious weeds, stones, and debris increase the costs of planting, care, and digging.

A supply of water for irrigating must also be considered. In California, only in the north coastal valleys receiving a heavy rainfall can a nursery of cuttings be grown successfully without irrigation, and there much better vines are produced with irrigation. Nowhere in California is it practicable to grow bench grafts without irrigation.

As bench grafts are very easily broken in planting, they require much more careful attention in choosing the location for a nursery and in caring for it, particularly during the early part of the summer, than do cuttings. Since, moreover, they are expensive, every precaution should be used to secure a good stand. Very light sands allow the grafts to dry out before they get started. Heavy soils crust badly after a rain or irrigation, and many grafts may be injured in the breaking up of this crust. Hence an easily worked sandy loam is nearly always chosen for a nursery of bench grafts.

IRRIGATING THE NURSERY

Except for the irrigations immediately after planting, which have already been discussed, the frequency of applications and the quantity applied at each irrigation will be determined in each case by the soil and climatic conditions. The lighter the soil and the hotter the weather, the more frequently water is needed. The soil of a nursery of cuttings should not be allowed to dry more than 2 or 3 inches deep until the cuttings have rooted. When growing vigorously they should be irrigated only often enough to maintain a vigorous growth until the first of September. Thereafter irrigation in the coastal valleys should cease and in the interior valleys should be given less frequently in order to check the

vigorous growth and permit the wood to ripen. The soil must not become so dry that the vines wilt. Excessive drought causing wilting, may actually prevent good wood maturity.

The soil around the unions of grafted vines must be kept moist until the unions are solidly grown together and the grafts are growing with water absorbed by the stock roots. This will be a week or two after the first removal of the scion roots. Thereafter the irrigation of a nursery of bench grafts does not differ from that of a cutting nursery.

Only the soil that has become dry needs to be wet at each irrigation. Early in the season, especially, heavy irrigations that might keep the

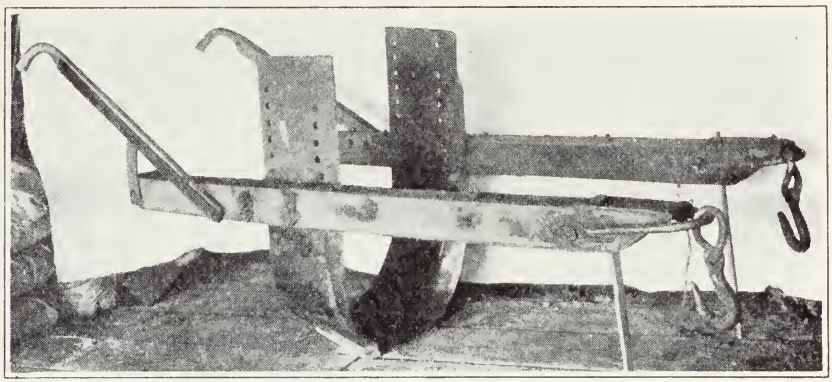


Fig. 13.—Nursery digger.

soil saturated with water for 2 or 3 days must be avoided. Later in the season the vines may remove the water from the soil to a depth of 3 or 4 feet, and then the soil should be wet to that depth when irrigated.

DIGGING THE NURSERY

The vines in the nursery can be dug up as soon as they have lost their leaves in the autumn. In a small nursery one may conveniently use a turning plow to remove as much soil as possible along the row of vines on one side and then take out the vines with a shovel or nursery spade. In large nurseries, the vines are dug up with a nursery digger (fig. 13) drawn by a tractor. The digger cuts the roots, loosens the vines, and lifts them slightly so that they can be easily pulled out by hand.

GRADING ROOTED VINES

Rootings or grafts should be graded into two or more grades as they are dug. A No. 1 rooting should have one or more good, well-matured canes at least 8 inches long and should have several good roots at the base, at least one of which is ⅛ inch or larger in diameter. It should also be free

Fig. 14.—A bundle of fifty No. 1 rootings is shown in *a*. Bundle *b* consists of twenty-five one-year-old No. 1 bench graft; the tops have been cut back in the customary manner for convenience in handling.

from any dead or injured areas on the body of the rooting and of normal length (fig. 14). No. 2 is any live rooting that fails to meet the specifications for No. 1 grade. Some nurserymen make three grades, the first of which, usually called "Jumbo," is comprised of the largest vines. The minimum quality of the No. 1 grade then remains as defined here.

A No. 1 graft has a complete and solid union in addition to the specifications given for a No. 1 rooting (fig. 14). A yield of 50 per cent of No. 1 bench grafts is considered satisfactory with a stock that works easily like St. George. Other stocks, more difficult to bench-graft, may yield only 25 or 30 per cent. It is impractical to bench-graft any stock that yields less than 25 per cent No. 1 rooted grafts. Such stocks should be rooted from cuttings or layers and then grafted; or better still, budded after the stock rootings are planted in the vineyard.

Only No. 1 rootings or grafts should be planted in the vineyard. The No. 2 grade may be replanted in the nursery for another year, after which a large percentage of them will make the No. 1 grade.

STORING ROOTED VINES

As rooted cuttings and bench grafts are much more easily injured by drying out than are cuttings, they must be handled more carefully and are best stored in cool, moist sand or soil. A shaded place, either the north side of a building or under large evergreen trees, is best. The sand

Fig. 15.—The correct manner of heeling in rooted vines or bench grafts.

or soil must be well drained; if there is any difficulty, a pile of sand or sandy soil raised a foot or two above the soil level will insure good drainage.

The rootings or grafts are usually sorted into bundles of 25 or 50 each. As large bundles may dry out badly on the inside and the vines may thus be severely damaged, small bundles are safest. The vines (in the bundles) are "heeled in" in a slightly inclined position (fig. 15). The soil about the roots must be firmly packed by tramping, and the vines nearly covered over with the sand or soil. In dry weather the soil should be settled thoroughly with water after the vines are heeled in and before they have a chance to dry out.

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